

CLAIMS

1. An ultrasonic flowmeter comprising a plurality of flow rate measurement units for measuring a flow rate of a fluid in a pipe by using an ultrasonic wave in mutually
5 different measurement principles.

2. An ultrasonic flowmeter comprising:
a plurality of flow rate measurement units for measuring a flow rate of a fluid in a pipe by using an
10 ultrasonic wave in mutually different measurement principles; and
a transducer unit for carrying out an interconversion between an acoustic signal and electric signal by being mounted onto the pipe and being shared
15 among a plurality of the flow rate measurement units.

3. An ultrasonic flowmeter comprising:
a first flow rate measurement unit for detecting a flow rate of a fluid in a pipe by using a transit time
20 method;
a second flow rate measurement unit for detecting a flow rate of a fluid in the pipe by using a pulse Doppler method;
a plurality of first and second transducer units,
25 being mounted onto the pipe in which a fluid as the subject

of measurement flows through, each of which carries out an interconversion between an acoustic signal and electric signal; and

a transducer changeover unit for making the first
5 and second flow rate measurement units share the transducer unit.

4. The ultrasonic flowmeter according to claim 3, wherein

10 a plurality of said first and second transducer units are mounted onto said pipe with the first and second transducer units mutually on the opposite sides across the axis of the pipe and at mutually displaced positions in the flow direction of said fluid,

15 said first flow rate measurement unit measures a flow rate of the fluid by measuring the time difference between a propagation time of an acoustic signal which is transmitted from the first transducer unit and received by the second transducer unit, and a propagation
20 time of an acoustic signal which is transmitted from the second transducer and received by the first transducer, and

said second flow rate measurement unit acquires a flow velocity profile of the entire diameter of the
25 pipe by combining the measurement values of flow velocity

profiles from the center to the pipe wall on the far side as seen from the aforementioned respective transducers from among the flow velocity profile measured by using each of the first and second transducers.

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5. The ultrasonic flowmeter according to claim 3, wherein

a plurality of said first and second transducer units are placed on the same side of said pipe mutually
10 apart from one another along the flow direction of said fluid,

said first flow rate measurement unit measures a flow rate of the fluid by measuring the time difference between a propagation time of an acoustic signal which
15 is transmitted from the first transducer unit and received by the second transducer unit after being reflected by the wall of the pipe and that of an acoustic signal which is transmitted from the second transducer unit and received by the first transducer unit after
20 being reflected by the wall of the pipe, and

said second flow rate measurement unit calculates a flow velocity profile in the axial direction of the pipe based on the difference of a velocity distribution to the wall of the pipe measured by each of the first
25 and second transducer units.

6. The ultrasonic flowmeter according to claim 3,
wherein

5 said first flow rate measurement unit includes
a pair of transducer units, being mounted onto said
pipe, for carrying out an interconversion between an
acoustic signal and an electric signal,

a transmission pulse generation unit for applying
a transmission pulse to the transducer units for an
10 ultrasonic transmission,

a receiving signal amplifier control unit for
inputting an ultrasonic receiving signal received at
the transducer units,

an analog/digital (A/D) conversion unit for
15 converting the receiving signal to a digital signal,

a propagation time operation unit for operating
a propagation time difference from a propagation time
measured by switching a transmission side and reception
side of a pair of the transducer units alternatively,

20 a flow rate calculation unit for calculating a flow
rate based on the propagation time difference, and

a transmission & reception timing control unit,
being equipped commonly to said second flow rate
measurement unit, for controlling the transmission pulse
25 generation unit and the A/D conversion unit.

7. The ultrasonic flowmeter according to claim 3,
wherein

said second flow rate measurement unit includes
5 a transducer unit, being mounted onto said pipe,
for carrying out an interconversion between an acoustic
signal and an electric signal,

a transmission pulse generation unit for applying
a transmission pulse to the transducer units for an
10 ultrasonic transmission,

a receiving signal amplification control unit for
inputting an acoustic signal received at the transducer
unit,

an analog/digital (A/D) conversion unit for
15 converting the received signal to a digital signal,

a flow velocity profile operation unit for
measuring a flow velocity profile of said fluid within
the cross section of the pipe based on a Doppler shift
frequency of an ultrasonic wave which is transmitted
20 and received between the transducer unit and the fluid,

an integral operation unit for determining a flow
rate by integrating the flow velocity profile, and

a transmission & reception timing control unit,
being equipped commonly with said first flow rate
25 measurement unit, for controlling the transmission pulse

generation unit and the A/D conversion unit.

8. An ultrasonic flow rate measurement method for measuring a flow rate of a fluid within a pipe by using
5 an ultrasonic wave,

measuring a flow rate by a plurality of flow rate measurement units, which uses mutually different measurement principles, sharing a plurality of transducer units, each of which, being mounted onto the
10 pipe, carries out an interconversion between an acoustic signal and an electric signal, and changing over a connection of the transducer unit for each of the flow rate measurement units.

- 15 9. The ultrasonic flow rate measurement method according to claim 8, comprising

a plurality of said flow rate measurement units which includes a first flow rate measurement unit for detecting a flow rate of a fluid within said pipe by
20 using a transit time method and a second flow rate measurement unit for detecting a flow rate of the fluid within the pipe by using a pulse Doppler method; and the steps of

mounting said first and second transducer units
25 on the mutually opposite sides across the axis of the

pipe and at mutually displaced positions in the flow direction of the fluid,

the first flow rate measurement unit measuring a flow rate of the fluid by measuring a time difference
5 of a propagation time of an acoustic signal transmitted by the first transducer unit and received by the second transducer unit from that of an acoustic signal transmitted by the second transducer unit and received by the first transducer unit, and

10 the second flow rate measurement unit calculating a flow velocity profile for the entire diameter of the pipe by combining measurement values from the center of the pipe to the pipe wall on the opposite side viewed from the first and second transducer units respectively,
15 of flow velocity profiles which are measured by the aforementioned transducer units respectively.

10. The ultrasonic flow rate measurement method according to claim 8, comprising

20 a plurality of said flow rate measurement units which includes a first flow rate measurement unit for detecting a flow rate of a fluid within said pipe by using a transit time method and a second flow rate measurement unit for detecting a flow rate of the fluid
25 within the pipe by using a pulse Doppler method; and

the steps of

placing said first and second transducer units on the same side of the pipe and at mutually separated positions in the flow direction of the fluid,

5 the first flow rate measurement unit measuring a flow rate of the fluid by measuring a time difference of a propagation time of an acoustic signal transmitted by the first transducer unit, reflected by the wall of the pipe and received by the second transducer unit from
10 that of an acoustic signal transmitted by the second transducer unit, reflected by the wall of the pipe and received by the first transducer unit, and

 said second flow rate measurement unit calculating a flow velocity profile in the axial direction of the
15 pipe based on the difference of a velocity distribution to the wall of the pipe measured by each of the first and second transducer units.

11. An ultrasonic flow rate meter capable of measuring
20 a flow rate by a pulse Doppler method and a transit time method simultaneously in parallel by comprising:

 at least one pair of electric/ultrasonic transducers necessary for measuring a flow rate by a transit time method;

25 a hardware unit for providing at least one pair

of electric/ultrasonic transducers with a pulse signal necessary for measuring a flow rate by the pulse Doppler method and necessary for measuring a flow rate by the transit time method;

5 a detection circuit for detecting a Doppler frequency shift from a received signal obtained from a discretionary transducer including the one pair of electric/ultrasonic transducers;

 a conversion circuit for amplifying and
10 analog/digital-converting a first received signal obtained by an ultrasonic pulse transmission from the upstream to the downstream, and a second received signal obtained by an ultrasonic pulse transmission from the downstream to the upstream, both by the one pair of
15 electric/ultrasonic transducers; and

 a control unit for calculating a flow rate from the detected Doppler frequency shift by the pulse Doppler method and also a flow rate from the output of the conversion circuit by the transit time method.

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12. The ultrasonic flow rate meter according to claim 11, further comprising

 a second electric/ultrasonic transducer only used for measuring a flow rate by the pulse Doppler method,

25 wherein

said hardware unit provides both said one pair of electric/ultrasonic transducers and the second electric/ultrasonic transducer with a transmission pulse signal, and

5 said detection circuit detects said Doppler frequency shift from a received signal obtained from the second electric/ultrasonic transducer.

13. The ultrasonic flow rate meter according to claim
10 11, wherein

 said at least one pair of electric/ultrasonic transducers comprises a single pair only, and the ultrasonic flow rate meter further comprises

 a switch unit, being inserted among an input of
15 a pulse signal output and said conversion unit of said hardware unit for a Doppler method and one transducer of the one pair only of electric/ultrasonic transducers, for connecting a circuit only for the duration of a measuring period by the pulse Doppler method, wherein

20 said detection circuit detects said Doppler frequency shift from a received signal which is an echo of an ultrasonic pulse output from the one transducer.

14. The ultrasonic wave flow rate meter according to
25 claim 13, wherein

said control unit and hardware unit collaborate in changing flow rate measurement modes, i.e., a pulse Doppler method, a transit time method and a both simultaneously method, according to an external command
5 or signal.

15. An ultrasonic flow rate meter capable of carrying out a flow rate measurement by changing over between the one with a pulse Doppler method and the one with
10 a transit time method by comprising:

at least one pair of electric/ultrasonic transducers necessary for measuring a flow rate by a transit time method;

a pulse generation unit for providing the one pair
15 of electric/ultrasonic transducers with a pulse signal necessary for measuring a flow rate by the transit time method to generate and output a pulse signal, to one of the one pair of electric/ultrasonic transducers, necessary for measuring a flow rate by the pulse Doppler
20 method;

a detection circuit for detecting a Doppler frequency shift necessary for calculating a flow rate by the pulse Doppler method by using one discretionary transducer including the one pair of electric/ultrasonic
25 transducers;

a changeover unit for enabling an amplification and analog/digital conversion of a first received signal obtained by an ultrasonic pulse transmission from the upstream to the downstream and of a second received signal
5 obtained by an ultrasonic pulse transmission from the downstream to the upstream by the above mentioned resources of the present claim; and

a control unit for calculating a flow rate by the pulse Doppler method from the detected Doppler frequency
10 shift and calculating a flow rate by the transit time method from a result of the analog/digital conversion.

16. The ultrasonic flow rate meter according to claim 15, wherein

15 said detection circuit comprises an amplifier in a stage in front thereof and one pair of analog/digital converters for processing a real part of data and an imaginary part of data respectively at a later stage,

said changeover unit comprises
20 one pair of single-pole dual-throw switch units, being inserted immediately before the one pair of analog/digital converters, for connecting a circuit only for the duration of a measurement period for a pulse Doppler method, while connecting an output of the
25 amplifier to one input of the one pair of analog/digital

converters, and further comprises

a second switch unit whose common terminal is connected to an output terminal of said pulse generation unit and an input terminal of the detection circuit,
5 and whose one pair of contacts are connected to said one pair of electric/ultrasonic transducers, wherein

the changeover unit controls in such a way as to change over between the one pair of single-pole dual-throw switch units and the second switch unit for
10 connecting an input of the amplifier to one of the transducers during a measurement period for the pulse Doppler method and changes over to the second switch unit during a measurement period for the transit time method according to a measurement algorithm thereof.

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17. The ultrasonic flow rate meter according to claim 16, wherein

said at least one pair of electric/ultrasonic transducers are a plurality of pairs of transducers,

20 the second switch unit is a single-pole switch comprising two times the plural number of contacts which are connected to the plural pairs of transducers one by one, and

said changeover unit allocates a measurement
25 period of a pulse Doppler method and that of a transit

time method to each pair of the plural pairs of transducers and, for the each pair, changes over the second switch unit so that an input of the amplifier is connected to one of the applicable pair of transducers during a measurement period of the pulse Doppler method, while
5 the amplifier is connected with the applicable pair of transducers for a measurement period of the transit time method according to a measurement algorithm thereof.

10 18. The ultrasonic flow rate meter according to claim 15, wherein

said control unit and said changeover unit collaborate in changing flow rate measurement modes, i.e., a pulse Doppler method, a transit time method and
15 a both simultaneously method, according to an external command or signal.